PATENT ABSTRACTS OF JAPAN

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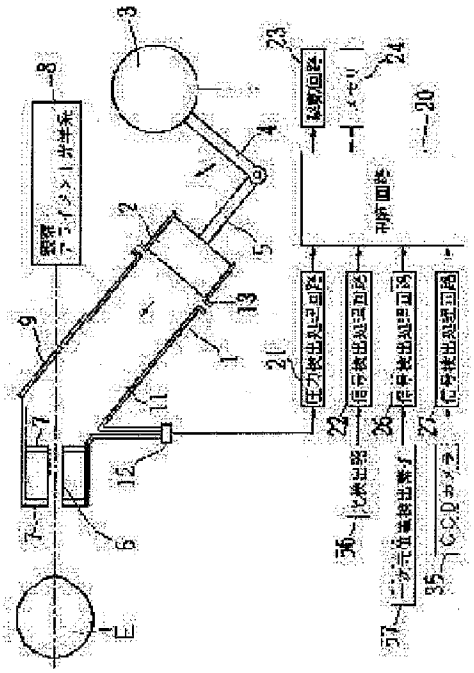
(54) NONCONTACT TONOMETER

(57)Abstract:
PROBLEM TO BE SOLVED: To lessen a burden on an examined eye by eliminating an excess fluid jet in measurement.
SOLUTION: A noncontact tonometer for measuring ocular tension in an examined eye by jetting fluid in a cylinder compressed by a piston toward the examined eye comprises a pressure detecting means for detecting the pressure of the fluid, a working distance detecting optical system having a projecting optical system for projecting a working distance detecting luminous flux onto the examined eye and a detecting optical system for detecting the working distance detecting luminous flux reflected by the examined eye cornea, a pressure variation detecting means for detecting a pressure variation per given time from the detection result of the pressure detecting means after the detecting optical system detects a given change signal after the fluid jet, and a power control means for feeding power to the piston drive, if the pressure variation per time is smaller than a given preset value, until a given cornea deformation is detected and for stopping the power feed to the piston drive, if the pressure variation is large than the given preset value, before the given cornea deformation is detected.



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CLAIMS

[Claim(s)]
[Claim 1] In the non-contact type tonometer which turns to optometry-ed the fluid in the cylinder compressed by the piston, blows off, and measures the intraocular pressure examined the eyes Working distance detection optical system with a pressure detection means to detect the pressure of a fluid, the floodlighting optical system which floodlights the flux of light for working distance detection to optometry-ed, and the detection optical system which detects the flux of light for working distance detection reflected by the cornea examined the eyes, A pressure variation detection means to detect the pressure variation per predetermined time by the detection result of said pressure detection means after said detection optical system detects a predetermined changing signal after fluid jet, Supplying power to a piston drive is performed until predetermined cornea deformation detects, when the pressure variation per time amount is smaller than a predetermined default. It is the non-contact type tonometer characterized by having the power control means which suspends the supplying power to a piston drive before predetermined cornea deformation is detected, when larger than a predetermined default.
[Claim 2] In the non-contact type tonometer which turns to optometry-ed the fluid in the cylinder compressed by the piston, blows off, and measures the intraocular pressure examined the eyes Working distance detection optical system with a pressure detection means to detect the pressure of a fluid, the floodlighting optical system which floodlights the flux of light for working distance detection to optometry-ed, and the detection optical system which detects the single dimension location of the flux of light for working distance detection reflected by the cornea examined the eyes, A pressure variation detection means to detect the pressure variation per predetermined time by the detection result of said pressure detection means after said detection optical system detects a predetermined changing signal after fluid jet, Non-contact type tonometer characterized by having the power control means to which the halt stage of the supplying power to a piston drive is changed based on the pressure variation per time amount.
[Claim 3] In the non-contact type tonometer which turns to optometry-ed the fluid in the cylinder compressed by the piston, blows off, and measures the intraocular pressure examined the eyes Working distance detection optical system with the floodlighting optical system which floodlights the flux of light for working distance detection to optometry-ed, and the detection optical system which detects the flux of light for working distance detection reflected by the cornea examined the eyes, Non-contact type tonometer characterized by having the power control means which suspends the supplying power to a piston drive as that to which optometry-ed had a blink when the changing signal by said detection optical system was downed by the specified quantity.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention compresses a fluid, sprays optometry-ed, and relates to the non-contact type tonometer which measures intraocular pressure by detecting the deformation condition of the cornea examined the eyes.
[0002]
[Description of the Prior Art] The fluid from a fluid jet means is turned to optometry-ed, it blows off and the non-contact type tonometer which measures intraocular pressure based on detecting deformation of a cornea with the fluid which blew off is known. The cornea deformation detection system was constituted from optical system which irradiates light, and a photo detector which receives the amount of reflected lights in a cornea by the cornea, and predetermined deformation of a cornea is detected by getting to know that the amount of cornea reflected lights received by the photo detector became max.
[0003]
[Problem(s) to be Solved by the Invention] However, since he was trying to stop the drive of a fluid jet means after it was detected that the cornea was conventionally deformed into the predetermined condition that an intraocular pressure value is acquired, in equipment, there was a problem of hanging a burden on optometry-ed. That is, since it is not immediately stopped by jet of a fluid even if it stops the drive of a fluid jet means after detection of a predetermined deformation condition, an excessive gas blows off. Moreover, if optometry-ed has the blink of an eyelid, since the amount of cornea reflected lights which the photo detector of a cornea deformation detection system receives does not show a peak, the fluid of the set-up maximum pressure will be injected by optometry-ed.
[0004] This invention makes it a technical technical problem to offer the non-contact type tonometer which can mitigate the burden examined the eyes more in view of an upper trouble, without performing excessive fluid jet at the time of measurement.
[0005]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, it is characterized by equipping this invention with the following configurations.
[0006] (1) In the non-contact type tonometer which turns to optometry-ed the fluid in the cylinder compressed by the piston, blows off, and measures the intraocular pressure examined the eyes Working distance detection optical system with a pressure detection means to detect the pressure of a fluid, the floodlighting optical system which floodlights the flux of light for working distance detection to optometry-ed, and the detection optical system which detects the flux of light for working distance detection reflected by the cornea examined the eyes, A pressure variation detection means to detect the pressure variation per predetermined time by the detection result of said pressure detection means after said detection optical system detects a predetermined changing signal after fluid jet, Supplying power to a piston drive is performed until predetermined cornea deformation detects, when the pressure variation per time amount is smaller than a predetermined default. When larger than a predetermined default, before predetermined cornea deformation is detected, it is characterized by having the power control

means which suspends the supplying power to a piston drive.
[0007] (2) In the non-contact type tonometer which turns to optometry-ed the fluid in the cylinder compressed by the piston, blows off, and measures the intraocular pressure examined the eyes Working distance detection optical system with a pressure detection means to detect the pressure of a fluid, the floodlighting optical system which floodlights the flux of light for working distance detection to optometry-ed, and the detection optical system which detects the single dimension location of the flux of light for working distance detection reflected by the cornea examined the eyes, A pressure variation detection means to detect the pressure variation per predetermined time by the detection result of said pressure detection means after said detection optical system detects a predetermined changing signal after fluid jet, It is characterized by having the power control means to which the halt stage of the supplying power to a piston drive is changed based on the pressure variation per time amount.
[0008] (3) In the non-contact type tonometer which turns to optometry-ed the fluid in the cylinder compressed by the piston, blows off, and measures the intraocular pressure examined the eyes Working distance detection optical system with the floodlighting optical system which floodlights the flux of light for working distance detection to optometry-ed, and the detection optical system which detects the flux of light for working distance detection reflected by the cornea examined the eyes, When the changing signal by said detection optical system is downed by the specified quantity, it is characterized by having the power control means which suspends the supplying power to a piston drive as that to which optometry-ed had a blink.
[0009]
[Embodiment of the Invention] Hereafter, this example is explained based on a drawing. Drawing 1 is drawing having shown the side outline of the fluid injection device of the non-contact type tonometer, and the important section of a control system.
[0010] 1 is a cylinder part for air compression, to the horizontal line of the body of the tonometer, inclines and is prepared. 2 is a piston, 3 is a rotary solenoid, and if the charge (a current, electrical potential difference) which is drive energy is given to the rotary solenoid 3, a piston 2 will be pushed up upwards along with a cylinder 1 through an arm 4 and a connecting rod (piston rod) 5. The air compressed at the air compression room 11 which is open for free passage to a cylinder part 1 with a rise of a piston 2 blows off from a nozzle 6 towards the cornea examined [E] the eyes. Moreover, the rotary solenoid 3 is equipped with the coil spring without illustration, and if the charge given is cut, the piston 2 which went up according to the energization force to the downward direction of a coil spring will be dropped, and it will return to an initial valve position.
[0011] 7 is a transparent glass plate, and it makes observation light and alignment light penetrate while it holds a nozzle 6. Moreover, the glass plate 7 serves as a side attachment wall of the air compression room 11. 9 is the transparent glass plate formed in the tooth back of a nozzle 6, and it makes observation light and alignment light penetrate while it constitutes the posterior wall of stomach of the air compression room 11. Behind a glass plate 9, the optical system 8 for the observation mentioned later and alignment is arranged. 12 is a pressure sensor which detects the pressure of the air compression room 11. 13 is a degassing hole, and resistance until initial velocity is attached to a piston 2 by the degassing hole 13 can decrease, and it can obtain almost-like proportionally pressure variation to time amount at the time of the standup of a pressure.
[0012] 20 is a control circuit and the memory 24 for memorizing the drive circuit 23 for making the pressure detection processing circuit 21 for pressure-sensor 12, the signal detection processing circuit 22 for photodetector 56 of the cornea deformation detection optical system mentioned later, the signal detection processing circuit 26 for single dimension location sensing element 57 of working distance detection, the signal detection processing circuit 27 for CCD camera 35, and the rotary solenoid 3 drive, measurement data, etc. is connected.
[0013] Drawing 2 is the top view optical-system important section Fig. of the non-contact type tonometer. Image formation of the image illuminated by the source 30 of the infrared illumination light examined the eyes is carried out to CCD camera 35 through a beam splitter 31, an objective lens 32, a beam splitter 33, and a filter 34. A filter 34 penetrates the light of the light

source 30 and the light source 40 for alignment, and has the property of not penetrating, to the light of LED50 for cornea deformation detection mentioned later. The image which carried out image formation to CCD camera 35 is displayed on a monitor 36.
[0014] 40 is the infrared rays LED for alignment, it is reflected by the beam splitter 31 and the infrared light projected through the projection lens 41 is projected on optometry-ed from a transverse plane. Image formation of the cornea luminescent spot formed in cornea top-most vertices of LED40 is carried out to CCD camera 35 through a beam splitter 31 - a filter 34, and it is used for alignment detection of the direction of four directions.
[0015] 45 is LED for fixation target projection, it is reflected by the beam splitter 33 and the light of the fixation target 46 illuminated by LED45 goes to the optometry E-ed, after passing the projection lens 47. A ** person measures, where the fixation of the fixation target 46 is carried out to optometry-ed.
[0016] 50 is the infrared rays LED for cornea deformation detection, and light which carried out outgoing radiation of LED50 is made the abbreviation parallel flux of light by the collimator lens 51, and is floodlighted by the cornea examined the eyes. After the light reflected by the cornea passes the filter 53 which has the property of not penetrating, to the light of the light-receiving lens 52, the light source 30, and the light source 40, it reflects by the beam splitter 54, and it passes the pinhole plate 55, and is received by the photodetector 56. When optometry-ed is in a predetermined deformation condition (flat condition), the optical system for cornea deformation detection is arranged so that the light income of a photodetector 56 may become max.
[0017] Moreover, this cornea deformation detection optical system serves as a part of working distance detection optical system, it is floodlighted from LED50, and the light reflected by the cornea forms the index image which is a virtual image of LED50. The light of the index image passes the light-receiving lens 52, a filter 53, and a beam splitter 54, and they carry out incidence to the single dimension location sensing elements 57, such as PSD and a line sensor. If optometry-ed (cornea) moves in the direction of the working distance, in order that the index image by LED50 may also move in the single dimension location sensing element 57 top, a control circuit 20 acquires working distance information based on the output signal from the single dimension location sensing element 57. Moreover, a control circuit 20 gets to know a blink examined [a cornea deformation condition or] the eyes, and controls the drive of a solenoid 3 by the output signal from this single dimension location sensing element 57.
[0018] The actuation is explained in the non-contact type tonometer equipped with the above configurations. First, the case where there is no blink of an eyelid after measurement initiation is explained.
[0019] A ** person arranges the optometry E-ed to a position, operates a joy stick without illustration based on the alignment information displayed on a monitor 36, and performs alignment adjustment. The cornea luminescent spot formed of LED40 is made for alignment adjustment of the direction of four directions to become a reticle without the illustration displayed on a monitor 36, and predetermined relation. Alignment adjustment of the direction of the working distance is performed according to the range index displayed based on the working distance information acquired from the single dimension location sensing element 57. In addition, please refer to JP,7-23907,A by these people etc. about the detail of this alignment adjustment. Moreover, a test section can be moved based on the detection information on an alignment index image, and alignment can also be carried out automatically.
[0020] If alignment completion is detected based on the alignment information acquired from the single dimension location sensing element 57 and CCD camera 35, a control circuit 20 will emit the trigger signal of measurement initiation automatically (or input of the trigger signal by the ** person), and will start measurement. That is, a control circuit 20 gives the charge as drive energy which can operate to the rotary solenoid 3 through the drive circuit 23, and makes this drive.
[0021] If a charge is given to the rotary solenoid 3, a piston 2 will go up, the air of the air compression room 11 is compressed by the piston 2, and it is sprayed towards the cornea examined [E] the eyes from a nozzle 6 in the compressed air. The cornea examined [E] the eyes deforms gradually by the sprayed compressed air. Incidence of the reflected light by the

cornea of the light floodlighted from LED50 is carried out to a photodetector 56, and the deformation condition of a cornea is detected by the output signal from a photodetector 56. Moreover, since incidence of the cornea reflected light at this time is carried out also to the single dimension sensing element 57 side, deformation of a cornea is detected by the output signal of the single dimension location sensing element 57.

[0022] Drawing 3 is the pressure signal Ps by the output of a pressure sensor 12, the cornea deformation signal Qs by the output of a photodetector 56, the solenoid driving signal Ks, the location bias signal Ss by the output of the single dimension location sensing element 57, and drawing having shown the light income signal Rs serially.

[0023] If a piston 2 starts a rise, the air in the air compression room 11 will be compressed, and the pressure signal Ps by the pressure sensor 12 goes up to a linear mostly with a rise of a piston 2. It is sprayed while the pressure of the compressed air breathed out by the optometry E-ed from a nozzle 6 rises similarly.

[0024] Deformation starts the cornea examined [E] the eyes by the compressed air. When cornea deformation begins, the location (light-receiving location of the cornea reflected light) of the index image detected by the single dimension location sensing element 57 begins to show the same bias to the alignment completion location at the time of measurement initiation as the working distance became far. A control circuit 20 obtains the pressure P1 in the bias start point t1 (at the time of biasing to the time of alignment completion only for predetermined deltaS 1 minute), and memorizes this in memory 24. If the pressure of the air compression room 11 is obtained always or intermittently with the signal from a pressure sensor 12 and the pressure P2 which changed for pressure-buildup value delta P minutes is obtained from a pressure P1, a control circuit 20 will set the solenoid driving signal Ks to LOW that the drive of a solenoid 3 should be stopped, and will suspend charge supply.

[0025] Here, since a piston 2 goes up with inertial force even after the charge supply to a solenoid 3 is suspended, after the pressure detected with a pressure sensor 12 does not fall immediately, either but continues a rise for a while, it descends. Therefore, deltaP is determined in consideration of a part for the pressure buildup after a drive halt of a solenoid 3 so that the peak q1 of the cornea deformation signal Qs may be acquired.

[0026] Beforehand, although deltaP is good also as a predetermined value, it is preferably defined with the function of pressure variation deltap (rate of pressure variation deltap/deltat) to predetermined time deltat [/ near the bias start point t1 of the location bias signal Ss (just before the location bias start point t1)]. That is, since delta p/delta t has the large inertial force of a piston 2 when large, and the pressure-buildup width of face after a drive halt of a solenoid 3 is large, deltaP is set up small. On the contrary, since the pressure-buildup width of face after a drive halt of a solenoid 3 is small when small, delta p/delta t sets up deltaP greatly.

[0027] When smaller than the default to which the above-mentioned delta p/delta t was beforehand set according to some causes (air leakage between a cylinder and a piston etc.), after the peak q1 of the cornea deformation signal Qs is acquired, the drive of a solenoid 3 is stopped, and it is made for a cornea to be in a flat condition certainly here.

[0028] Moreover, if cornea deformation begins, since the quantity of light of the cornea reflected light received by the single dimension location sensing element 57 will also change to the quantity of light at the time of alignment completion The drive of a solenoid 3 may be stopped to the timing from which the detection pressure force changed for delta P minutes instead of the bias start point t1 in the location bias signal Ss on the basis of the change start point t'1 (at the time of increasing only predetermined quantity of light deltaR 1 minute to the time of alignment completion) of the light income signal Rs.

[0029] Even after stopping the drive of a solenoid 3, although a piston 2 goes up with inertial force, in order that the energization force to the downward direction by the coil spring may work at a piston 2, the rate of a piston 2 is decreased with the energization force of a coil spring, and the gravity concerning a piston 2, and it stops, and comes to descend after that. Since peak value q1 comes to be acquired by the pressure buildup after a drive halt of a solenoid 3, a control circuit 20 calculates the about [of peak value q1 / time amount t2] mean-pressure value Pav (t), and the cornea deformation signal Qs processes predetermined intraocular

pressure conversion to this, and acquires an intraocular pressure value.
[0030] It can suppress spraying excessive air as mentioned above at the time of measurement. That is, after it is detected that deformation of a cornea deformed into the predetermined condition (flat condition), compared with the case where the drive of a solenoid 3 is stopped, measurement becomes possible by the weaker discharge pressure from the 1st ophathalmotonometry.
[0031] Next, the case where a blink examined the eyes is after measurement initiation is explained based on drawing 4 . If there is a blink examined the eyes, since the cornea reflected light will not carry out incidence to a photodetector 56, the cornea deformation signal Qs hardly continues changing. Since the peak of Qs is not acquired in a configuration of waiting for the peak of the cornea deformation signal Qs, and stopping the drive of a solenoid 3, the compressed air blows off to the maximum pressure set up like pressure signal P's.
[0032] On the other hand, if alignment is made to complete and a blink examined the eyes is after measurement initiation, the light income signal Rs of the single dimension location sensing element 57 will be downed greatly. Moreover, the location bias signal Ss of the working distance detected is also greatly biased in the direction in which the working distance becomes short. A control circuit 20 detects that detection or the light income signal Rs was downed only for deltaR 2 minutes in what the location bias signal Ss biased in the direction in which the working distance becomes short only for deltaS 2 minutes, and stops the drive of a solenoid 3. delta S2 and delta R2 are set up as a value which can detect the blink of an eyelid certainly. Measurement can be interrupted without this spraying an excessive discharge pressure at the time of blink generating. Moreover, a control circuit 20 displays that on a monitor 36 as a measurement error in this case.
[0033]
[Effect of the Invention] According to this invention, as it can measure, without applying unnecessary hydrostatic pressure to optometry-ed and an excessive discharge pressure is not sprayed at the time of blink generating, either, the burden to optometry-ed can be made to mitigate, as explained above. The high measurement result of precision is obtained by mitigating the burden examined the eyes.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the side outline configuration and control system of an air compressor style.
[Drawing 2] It is drawing which looked at the optical system near the nozzle of an air compressor style from the upper part.
[Drawing 3] the location by the pressure signal, the cornea deformation signal by the photodetector, the solenoid driving signal, and the single dimension location sensing element — a variation rate -- it is drawing showing a change of a signal and a light income signal with time.
[Drawing 4] the location by the pressure signal in case there is a blink of the eyelid examined the eyes, the cornea deformation signal by the photodetector, the solenoid driving signal, and the single dimension location sensing element -- a variation rate -- it is drawing showing a change of a signal and a light income signal with time.
[Description of Notations]
1 Cylinder Part
2 Piston
3 Rotary Solenoid
12 Pressure Sensor
20 Control Circuit
23 Drive Circuit
50 Infrared Rays LED
56 Photodetector
57 Single Dimension Sensing Element

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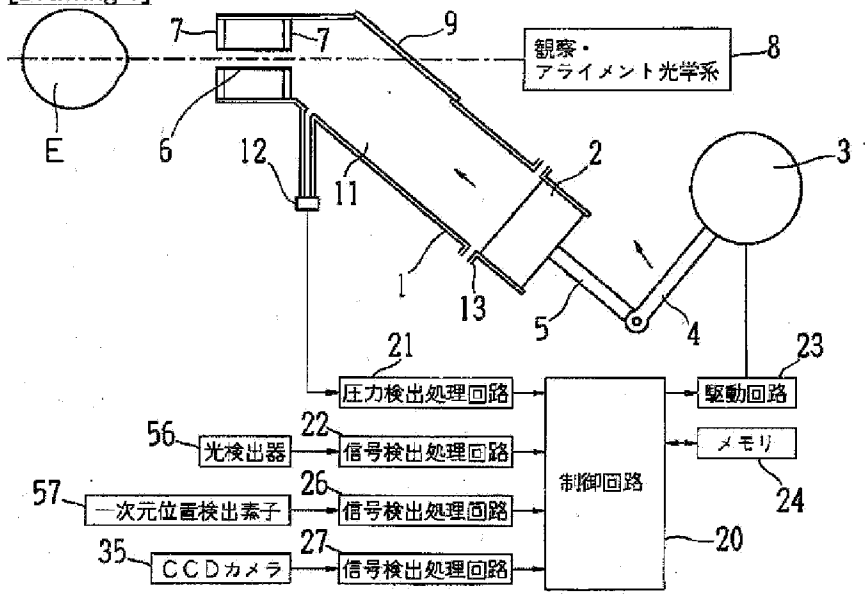
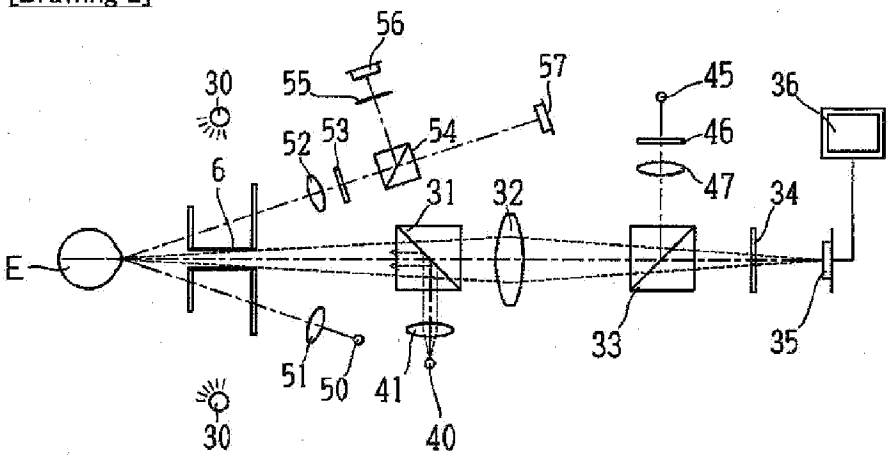
DRAWINGS

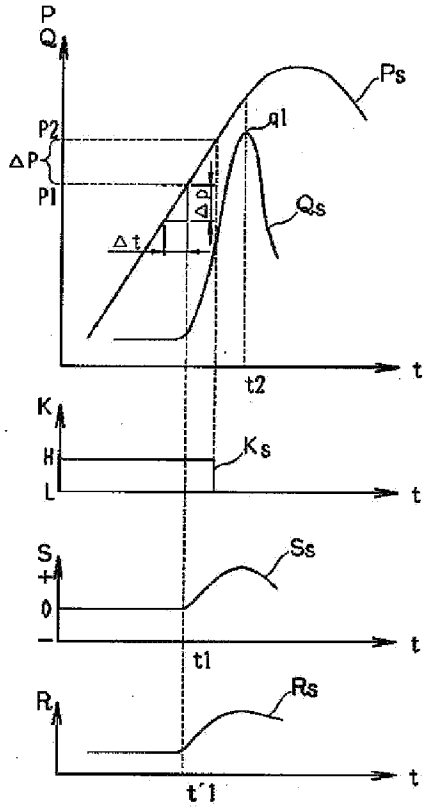
[Drawing 1]



[Drawing 2]



[Drawing 3]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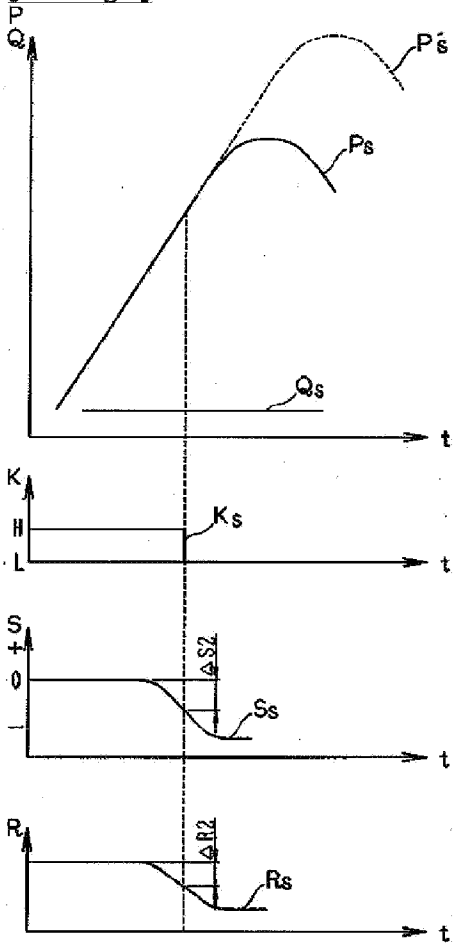
[Drawing 4]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